# Fabrication of simulated minor actinide containing fuel particles and analytical characterization methods

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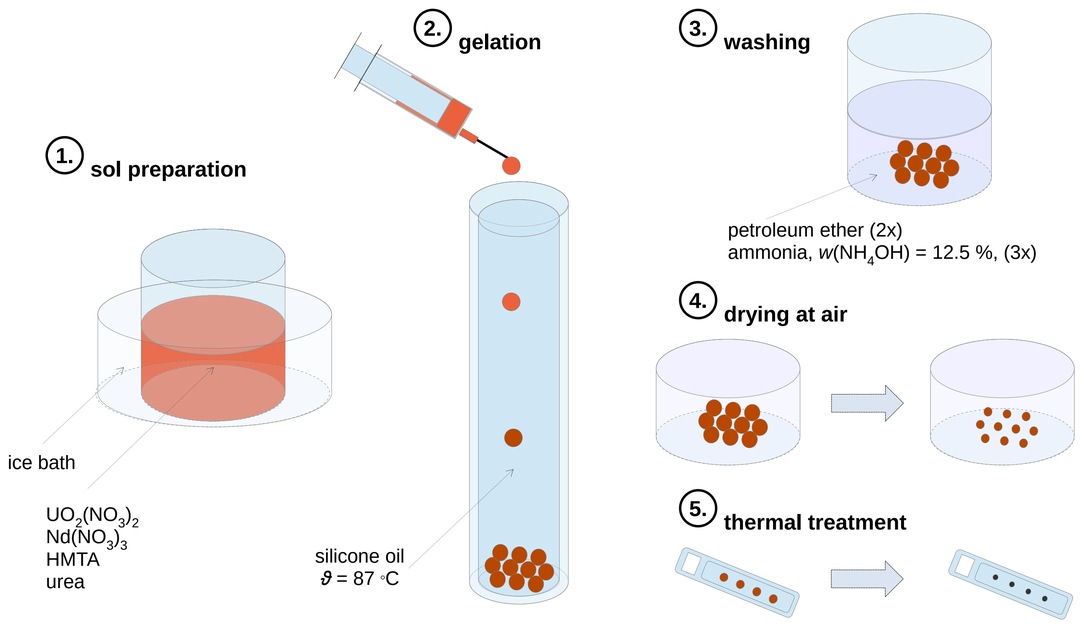
## Introduction

In the context of advanced nuclear fuel cycles including partitioning and transmutation, actinide co-conversion processes play an important role. Therefore, actinide ceramics are considered to be used as precursor for the fabrication of innovative fuels.

Suitable conversion methods are the sol-gel route by internal gelation (IG)[1] and the weak-acid resin process [2]. Both synthesis routes have the advantage of a dustless fabrication. Within the project ASGARD these methods were applied to prepare $UO_2/Nd_2O_3$ microspheres.

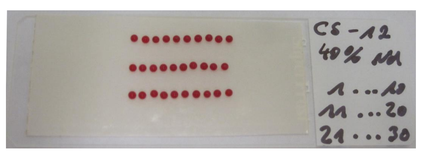
## Sol-gel method by internal gelation

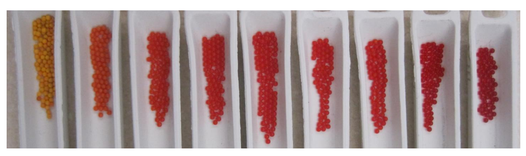
### Synthesis

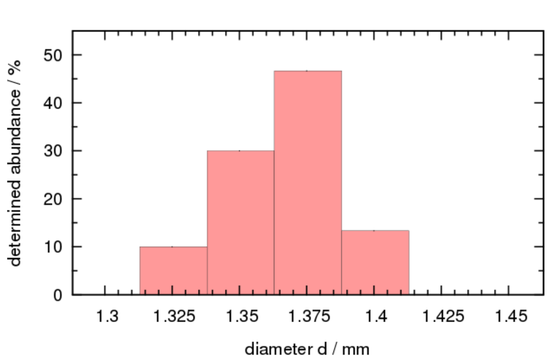


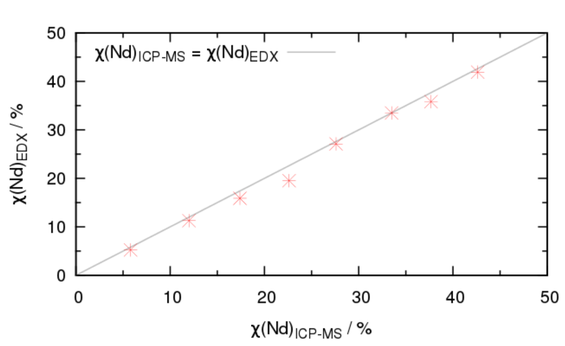

### Characterization

- U/Nd microspheres ($\chi$(Nd) = 0 - 42.63 %) prepared via internal gelation.

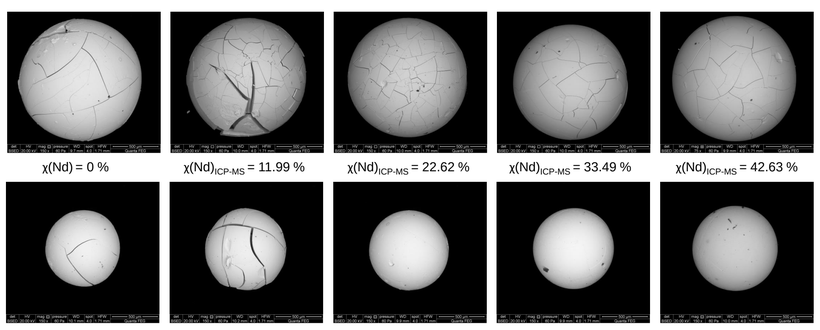


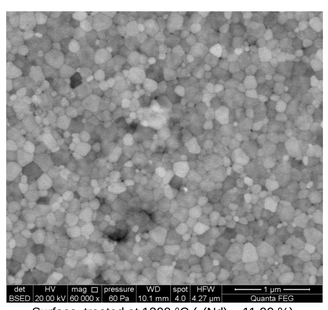





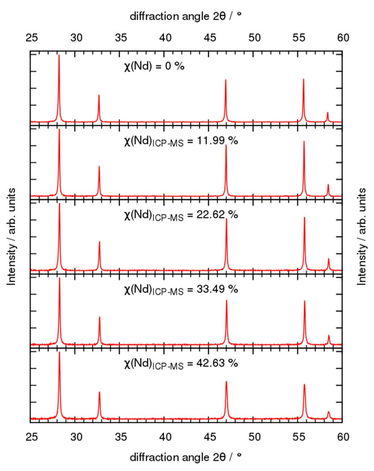



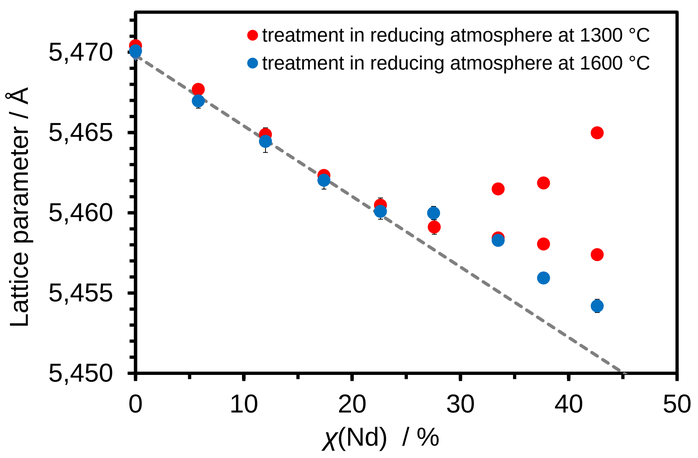

- Average masses and diameters with small standard deviations.
- EDX results (top 5 µm) in good correlation with ICP-MS measurements.





Surface, treated at 1300 °C (χ(Nd) = 11.99 %).

- Sphericity proven by SEM, cracks found for air dried particles.
- Proper surface integrity after treatment in $H_2$:Ar.
- Crack formation proven by ESEM (850 Pa → 70 Pa).

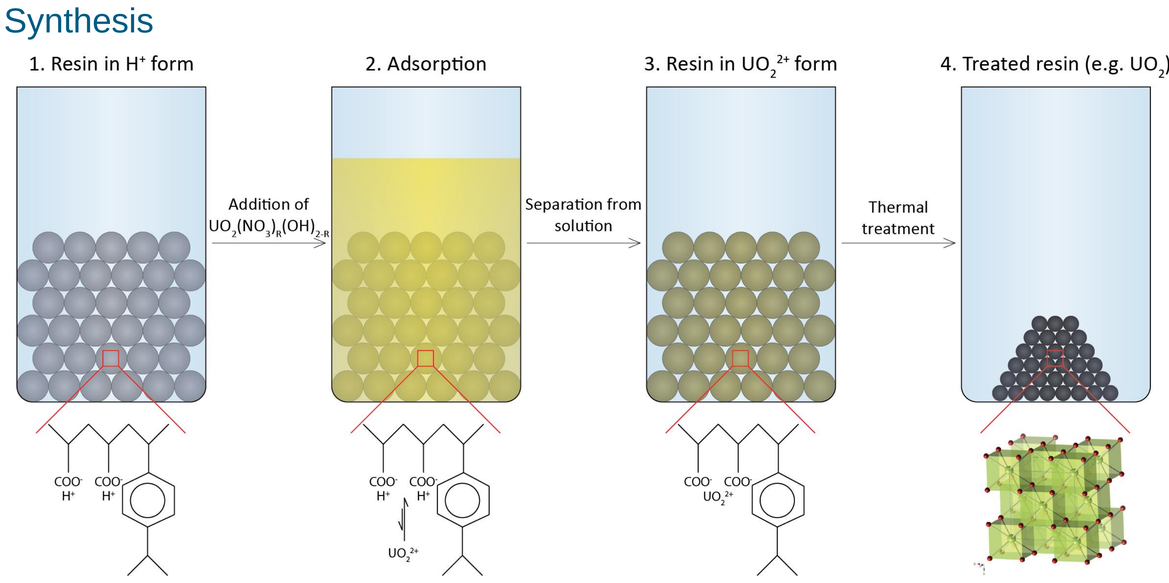



- Linear dependence of lattice parameter on $\chi$(Nd) ≤ 25 %.
- Unexpected behaviour for $\chi$(Nd) > 25 % (1300 °C → 2 phases).

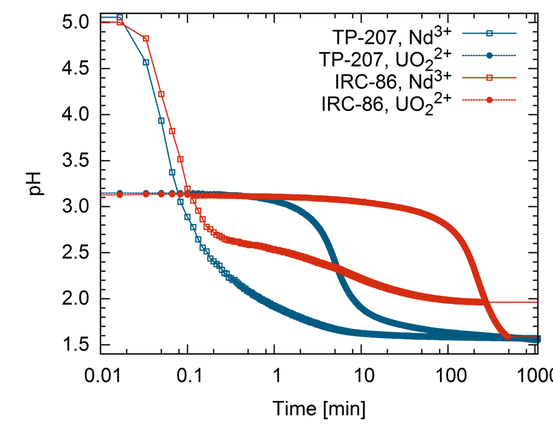
## Weak-acid resin process

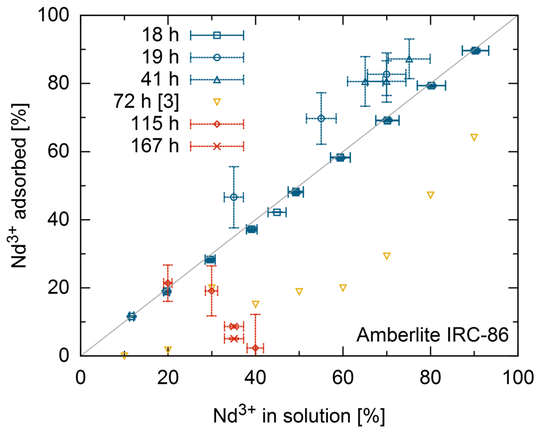
### Synthesis



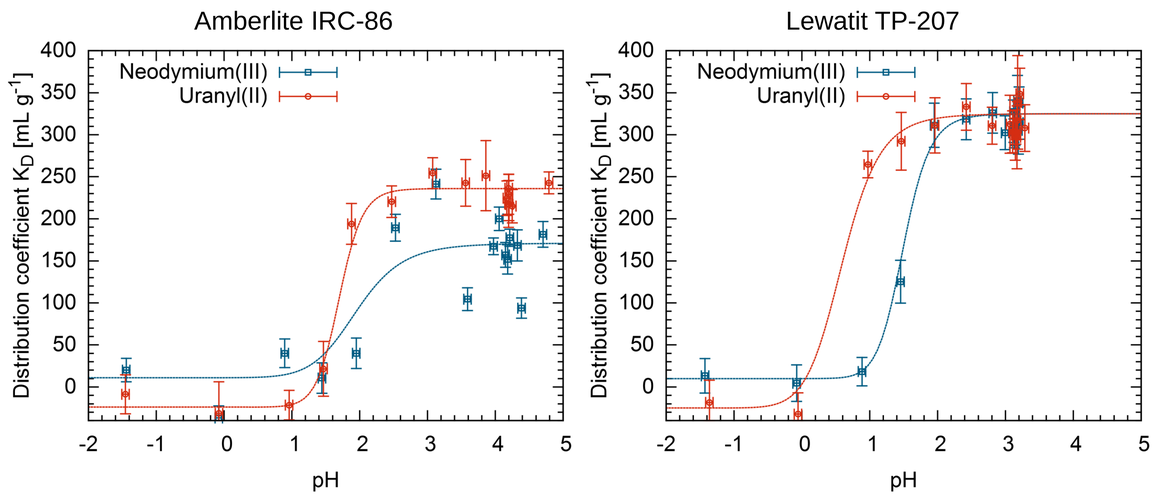

- Example for production of $UO_2$ microspheres using Amberlite IRC-86.

### Characterization

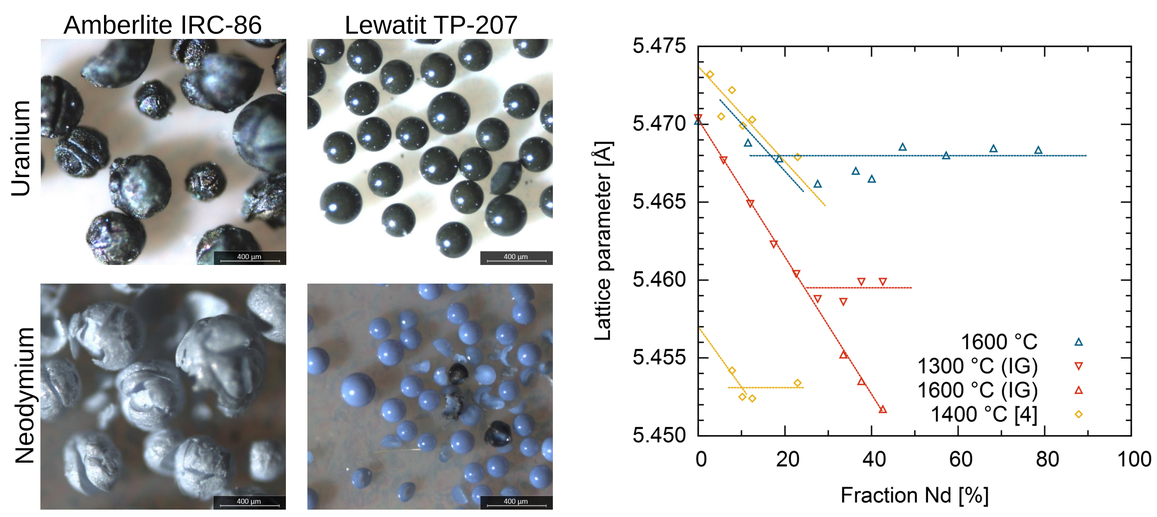



- Adsorption equilibrium reached after 18 h.
- Decrease of $Nd^{3+}$ fraction after t > 18 h
- $Nd^{3+}$ kinetically favoured; $UO_2^{2+}$ thermodynamically favoured.




- The pH value is a major factor on the adsorption.




- Treated in air: Amberlite IRC-86 broken, Lewatit TP-207 suitable.
- No equilibrium solid solution has been achieved (reducing atmosphere).

[1] J. L. Collins et al., *Radiochimica Acta*, 42: p. 121-134 (1987).
[2] K. Notz et al., *Radiochimica Acta*, 25: p. 153-160 (1978).
[3] M. Weidenfeld, Diplomarbeit, FH Aachen University of Applied Sciences (2010).
[4] L. Desgranges et al., *Inorganic Chemistry*, 51(17): p. 9147-9149 (2012).

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